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THE INFLUENCE OF DEGENERATION OF ONE VAGUS NERVE UPON THE DEVELOPMENT OF PNEUMONIA

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Since Galen's time experiments have been made upon the vagus nerve and it has been generally known that section of both nerves leads to an early death of the animal. It was however in the seventeenth century that it first became known, through the observations of Valsalva and Morgagni, that the section of the vagi causes lesions in the lungs, lesions which were designated by Vieussens as inflammation. Since this period numerous studies have been made regarding the nature of the influence of cutting of the vagi which leads to inflammation of the lungs, to pneumonia. Many investigators were of the opinion that the section of the nerves leads directly to changes in the pulmonary tissue. The last representative of this group of investigators was Schiff who in the forties of the last century described the lesion as being due to a *neuro-paralytic* action. At the same period, however, Traube carried out many series of well conducted experiments by which he seemed to prove that the section of both vagi causes lesions in the lung by paralysis of the oesophagus, which prevents the transportation of food into the stomach, and by paralysis of the nerves of the larynx, a paralysis which facilitates the entrance of food, saliva, and other foreign bodies into the trachea and the lungs. In other words, the pneumonia following section of both vagi was not due to direct changes in the lung tissue but indirectly to the entrance of foreign bodies through the trachea into the lung; the inflammation following section of both vagi was of the nature of 'aspiration

pneumonia.' In the last six or seven decades many more experiments have been made on the section of both vagi; but all investigators have accepted Traube's interpretation, namely, that the section of the vagi does not cause directly any changes in the tissues. but that the section of the nerves leads to a 'foreign body pneumonia.'

In the above mentioned numerous experiments, as a rule, both vagi were cut; not very many experiments were made by cutting only one vagus. But when such an experiment was made, it was found practically invariably that cutting of one vagus produced neither any clinical effect during life nor were there pathological lesions of the lung at autopsies. I may add that our own experimental experience supports this finding: Cutting of one vagus of a normal dog never leads to a pulmonary disease or lesion.

In the course of the last eight years we carried out in this laboratory numerous experiments on the production of pneumonia by direct injection through the unoperated larynx into the bronchi of normal dogs of various micro-organisms capable of producing various forms of pneumonia. Most of our experiments were recently made with intrabronchial injections of culture of pneumococcus type I, and it was established that the degree of the disease which it produces or the length of time required for the fatal outcome depend upon the virulence of the organism as well as the quantity of the culture injected. Recently a long series of such experiments were carried out with a view of studying the *direct action of vagus nerves upon the development of pneumonia*. Since in these experiments the nerves of the oesophagus and of the larynx remained intact, any acceleration in the development of the disease or the pulmonary lesion could be ascribed only to the interruption of the nervous impulse normally transmitted through the intact vagus nerve to the lung tissue. We shall not enter here into the details of the experiments; but merely state briefly that: In one series of experiments one vagus was cut but no organisms insufflated; these animals, as mentioned above, remained normal. In another series of experiments a definite quantity of the culture was insufflated in normal dogs. These animals either remained alive or died with some pulmonary lesions many days after the injection. In a third series the same culture and the same quantity of it was insufflated on the same day and under the same condition as in the last mentioned series; but in these animals one vagus was cut either four days or ten or more days before the culture was insufflated. These experiments brought to light a striking result. *In the series in which one vagus was cut ten or more days before the insufflation of the culture nearly all*

animals died in less than twenty-four hours after receiving a certain (minimum) amount of the culture, while in the animals in which one vagus was cut four days before the injection or not cut at all, not a single animal died in such a short period, and most of them remained alive. In other words, a certain minimum quantity of culture which was injected ten or more days after one vagus was cut proved to be rapidly fatal; while the injection of the same quantity remained ineffective if no vagus was cut or was cut only a few days before the injection of the culture.

We shall confine ourselves here to the communication of these facts and to only one interpretation of them. First, these experiments show unmistakably that the integrity of a certain form of nerve impulses is indispensable for the normal resistance of the lung tissue to infection or intoxication; if one vagus nerve was cut ten days before the injection of a pneumococcus culture a certain minimum of the culture was nearly invariably rapidly fatal, while in a normal animal or in an animal in which one vagus was cut only a few days before the injection or not cut at all, the same minimum of culture has little or no effect.

Second, for the vessels of most of the tissues it is known that they are innervated by vasoconstrictors and vasodilators. It is further known that the vasoconstrictors degenerate about four days after the section of the nerves, while the vasodilators degenerate only about ten days or later after the section. If we assume that the lungs are also provided with vasoconstrictors and vasodilators and that these vasomotor fibres are carried to the lungs in the vagus nerves, we would have a plausible explanation for the phenomena with which we were confronted in our experiments, namely, cutting of the vagi four days previous to the culture injection is capable of causing degeneration of only the vasoconstrictor nerve fibres, which may not be indispensable to the upholding of the normal activity of the lung tissue. If, however, the injection is made about ten days or longer after the cutting of one vagus, also the vasodilators are degenerated and their integrity may be indispensable for upholding the circulation and the normal resistance of the lung tissue to infection or intoxication by a virulent culture of pneumococcus type I.

At any rate, our experiments brought out the facts that nerve impulses are running through the vagus nerves which are important to the upholding of the normal resistance of the lung tissue itself. That even one vagus nerve is an important factor in this process; and that these activities of the vagus nerves can be recognized only after an intrabronchial or intratracheal injection of a virulent culture ten days after the cutting of one vagus.

Furthermore, the fact that the intrabronchial injection of a minimum culture proved fatal only when the injection was made ten days after the section of one vagus and the further consideration of the fact that it takes about ten days for the degeneration of vasodilators lend support to the assumption that it is the degeneration of the vasodilators which is responsible for the fatal results observed in our experiments.

ON THE ETHOLOGY OF CHITON TUBERCULATUS[1]

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Communicated by E. L. Mark, September 5, 1919

Chitons of the species *C. tuberculatus* Linn. are an important element in the shore-fauna of the Bermuda Islands. Their large size, their abundance, and the diversity of the habitats which they occupy within the tidal zone, make them animals appropriate for a variety of investigational purposes—notably for study of the relations found among the features of local habitats, on the one hand, and, on the other, certain definite sensory and other modifications of these animals which develop with the advancing age of a chiton. The organization of the Placophora, probably primitive with reference to that of other molluscs, makes it important also to obtain physiological evidence as to the characteristics of the nervous system in these animals. On the structural side it is well known that the chiton central nervous system is in the form of strands, containing perikarya throughout their length, but with no concentrations of these cells into distinct ganglionic enlargements.

We find in *Chiton tuberculatus* decided indications of but a relatively incipient degree of nervous centralization. The autonomy of the several portions of the body, or of the parts into which it may be artificially separated, is conspicuous. At the sides of the body, the parts (girdle, ctenidia, etc.) innervated by the pallial strands are pronouncedly homolateral in their responses. The coördinating mechanism for the production of pedal locomotor waves is locally contained. The absence of strong anterior nervous centralization is nicely indicated by the exhibition of backward creeping (especially in Ischnochiton) under proper conditions of stimulation by light.

Of the several kinds of sensory receptors which we have distinguished in *Chiton tuberculatus*, the nervous elements in the shell tegmenta, now for the first time proved to be photosensitive, are perhaps the most

important in determining the general habits of the animal. Through the mediation of the nervous elements of the shell-valves Chiton exhibits precise phototropic orientations. The younger individuals are photonegative, the older ones photopositive, to sunlight. Chitons of intermediate age are positive to weak daylight, negative to strong. The 'intermediate' age is generally in the neighborhood of six years (5 to 7 cms. length).[2] This alteration in the behavior of Chiton toward daylight as the animal becomes older is primarily responsible for the exhibition of a complex series of harmonious environmental interrelations. The progressive inversion in the sense of Chiton's phototropism is due to the elimination of the shell photoreceptors by erosion, thus conditioning in the older individuals a lower specific stimulating power of the light. Erosion of the shell is itself produced through normal growth effects, in part; more directly, by physical agencies of the environment and by the activities of various small organisms which come to live on the chiton shell.

The nature of the algal food, varying somewhat from place to place, and the presence of epiphytes, barnacles, tubiculous worms, and the like, on the dorsal surface of a chiton, determine automatically a certain degree of homochromic coloration. The established fact that a given Chiton tends to remain within a relatively small area for long periods, affords opportunity for the institution of correlations of this nature. These correlations concern practically every feature of the bionomics of Chiton: its method of feeding, its breeding habits, and other matters which have been studied; and they follow automatically in the wake of the changing phototropism of the animal, itself largely controlled by environmental causes. Granted the original condition that those inherited mechanisms for response present in the young post-larval chiton lead to its living under loosely piled small stones at the very upper limit of the tide, it can be shown that the 'adaptive' cycle of subsequent changes, leading ultimately to the life of the oldest individuals on brilliantly illuminated rock surfaces, is produced in automatic sequence. It is important that the environmental effects of a particular location are in general not such as to cause a chiton to become more closely adapted to the peculiarities of that situation, but on the contrary result in the animal's going somewhere else—namely, into a more brightly illuminated area, where the environment as a whole is in certain respects fundamentally different.

From the standpoint of the theory of adaptation, the most important result of our inquiry into the natural history of Chiton may be given thus:

a number of precise and intricate bionomic correlations result automatically from the animal's modes of reaction, mediated by a central nervous apparatus which is relatively diffuse, less centralized functionally than is that of other molluscs; the habits so expressed determine the nature of the environment in which the Chiton lives.

Full reports of these studies will be found in papers to appear in the *Journal of Experimental Zoölogy*, and in the *American Naturalist*.

[1] Contributions from the Bermuda Biological Station for Research, No. 112.
[2] cf. Crozier, W. J., These PROCEEDINGS, November, 1918.

THE NERVOUS ORGANIZATION OF A NUDIBRANCH[1]

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Having in mind the important position of the mollusca with respect to the evolutional elaboration of central nervous organs, we have sought to obtain evidence permitting a more precise statement of the functional relations between the peripheral and the ganglionic conducting pathways in a nudibranch, *Chromodoris zebra*. The absence of a shell in these animals, and certain more specific peculiarities of their construction, afford favorable conditions for such analysis. A full account of our observations is in press, to appear in the *Journal of Experimental Zoölogy*.[2]

The dorsally placed 'crown' of gills comprises in *Chromodoris* about 12 distinct plumes arising from a ridge almost surrounding the anal aperture. Each plume may contract independently. All of the plumes may also contract simultaneously, and the whole gill-crown may be concealed within a collared pocket. During the day-time, and under certain conditions of alkalinity and temperature in the seawater,[3] the plumes are extended. If a plume be lightly touched at one point, the common orm of response is constriction at that level, resulting in a slight swaying of the plume. More vigorous stimulation likewise leads to this locally confined unsymmetrical contraction, which however is now seen to spread distally from the site of activation, as a collapse and shrivelling of the plume, and is also accompanied by the downward pulling of the entire plume through the traction of muscles situated in the basal tissue of the gill-crown. Still stronger activation induces longitudinal shortening of the plume, both distally and proximally to the point of stimulation, and in the basal tissue.[4]

The polarity evident in these reactions of the single gill plumes has certain fundamental resemblances to that seen in the tentacles of sea anemones.[5] Like the latter, it pertains to other than tactile forms of activation (e.g., shading), is obliterated by magnesium sulphate anaesthesia, and persists in all its aspects in the plumes of an excised gill-crown (tied off basally to preserve internal pressure). It is therefore a local matter, conditioned by a self-contained nervous structure which conducts impulses more easily distalward than basally. The nature of this autonomous nervous equipment is defined by the fact that strychnine, in concentrations amply sufficient to affect certain other responses of the nudibranch known to be mediated by the central nervous ganglia, is without influence upon the responses of the gill plumes. The type of nonsynaptic conducting mechanism (nerve net) which is thus indicated for the gill crown, we attribute, on similar evidence, to all the peripheral parts of *Chromodoris*.

If the oral tentacle of one side of a *Chromodoris* be stimulated, the homolateral dorsal tentacle ('rhinophore') contracts together with the activated tentacle; the opposite oral tentacle does not respond. If however a 'rhinophore' be stimulated, the tentacle of the same side does not react with it, nor does the other 'rhinophore' respond. The same homolateral nature and irreciprocal character of nervous transmission between the several reacting parts is further found in a detailed study of the activities of the mouth and protrusable pharynx, tentacles, 'rhinophores,' and the anterior edge of the foot. Conduction such that a 'rhinophore' responds when its homolateral tentacle is stimulated disappears when the supra- and suboesophagal ganglia have been removed.

Under the influence of injected strychnine solution, we find that these reactions involving central, inter-organ transmission are profoundly modified. In general, the threshold for such reactions (now followed by a relatively long 'refractory interval') is lowered, the responses themselves enhanced. The irreciprocal character of the conduction, as between tentacle and 'rhinophore,' is abolished; so likewise is the normally pronounced homolateral bias of the reactions obliterated. There are other additional evidences of facilitated intraganglionic communication under strychnine. These effects are not manifest in deganglionated individuals treated with strychnine.[6, 7]

It may therefore be assumed that peripherally, in the body wall and its projecting outgrowths, there are nerve-nets concerned with local responses; that these nets are characteristically polarized; and that they are dominated by the central nervous system of the nudibranch, the latter

being essentially a synaptic system. It would appear that that primitive type of nervous organization predominantly present in such coelenterates as the sea-anemones, but preserved in vertebrates only among certain autonomous internal organs,[5] still forms in molluscs a highly important feature of the animal's action system.[8]

[1] Contributions from the Bermuda Biological Station for Research, No. 113.

[2] Crozier, W. J., and Arey, L. B., "Sensory reactions of Chromodoris zebra," *J. Exper. Zoöl., Phila.*, (in press).

[3] Crozier, W. J., 1919, *J. Gen. Physiol., Baltimore*, 1, No. 6.

[4] For more detailed treatment of the complex conditions here entering, consult papers cited in footnotes two and three.

[5] cf. Parker, G. H., 1919. *The Elementary Nervous System.* (Philadelphia.)

[6] Frölich (*Zs. Allgem. Physiol., Jena*, 11, 1910, p. 269) had already demonstrated that in *Aplysia* the site of action of strychnine is the 'cerebral' ganglion.

[7] Cushny (*Quart. J. Exp. Physiol., London*, 12, 1919, p. 153) points out that the depression of the reflex thresholds, rather than, as often held, the conversion of 'inhibition' to 'activation' (where reciprocal innervation is involved), is the essential feature of the strychnine effect.

[8] This conception of the nervous organization of *Chromodoris* agrees with the opinion held by Bethe respecting *Aplysia*, but the evidence here relied on is much more complete (cf. Bethe, *Allgem. Anat. u. Physiol. d. Nervensystems*, Leipzig, 1903).

ARE GENES LINEAR OR NON-LINEAR IN ARRANGEMENT?

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Communicated, August 13, 1919

As to the question whether the genes in a linkage system are linear or non-linear in arrangement, Morgan and his associates[1] still maintain their former view that the arrangement is strictly linear. I have questioned the validity of this view on the following grounds.[2] (1) The forces which link the genes together are possibly molecular rather than mechanical. If so, it is doubtful whether the entire system consists of a simple thread-like chain. (2) Construction of a model in three dimensions of the relations of the genes in the sex chromosome of *Drosphila ampelophila* as shown by the data of Morgan and Bridges,[3] and on their own assumption that distances are proportional to cross-over values, proves that the arrangement can not be linear. A similar reconstruction for the sex-linked genes of *D. virilis* shows the same thing for that species even more emphatically. (3) The linear hypothesis makes necessary the further assumption that cross-overs greater than 50% occur within the linkage system.

Such values have not been observed and are logically impossible. (4) The hypothesis of non-linear arrangement is simpler because it eliminates secondary hypotheses needed on the linear hypothesis to harmonize greater with lesser cross-over values, particularly the hypothesis of double crossing-over.

Point (1) is dismissed by Morgan and his associates with the remark that it is "probably not intended to be taken seriously." I, therefore, renew the suggestion and invite "serious" consideration of it. They argue that chromosomes are thread-like and that accordingly linkage-systems must be thread-like. This seems to me unconvincing, because we do not know how much of the visible chromosomes is composed of genes and how much is something else. Further it may be that the genes are not *in* the chromosomes at all but merely *attached* to them, especially if the attachments are molecular rather than mechanical. All the observational facts concerning linked genes would be equally well satisfied by such a view. It should be borne in mind that we have no evidence whatever that the chromosomes *are* genes but only that the genes are in some way connected with them. Accordingly the spatial relations of genes can not be legitimately inferred from the shape of the chromosomes.

Against point (2) the chief attack of Morgan and his associates is directed. No objection is made to the method employed of reconstruction in three dimensions, but the reliability of the data used is repeatedly assailed. Now the data consisted of Table 65 of Morgan and Bridges on which the authors based their Diagram I showing the arrangement of the genes as linear. Surely this same data could legitimately be used in testing the hypothesis that the arrangement is non-linear. Moreover the Table 65 is, so far as I know, the *only* table in which the authors have ever given a comprehensive summary of their data. At the head of the table, they say "In Table 65 all data so far secured upon the sex-linked characters are summarized." Now my model, based on actual measurements of distances indicated by Table 65, showed conclusively that the arrangement of the genes can not possibly be linear. No alternative is therefore left to Morgan and his associates except either to repudiate their Diagram I or to repudiate the data on which that diagram was ostensibly based. They choose the latter alternative. In discussing the relation to each other of any three genes, they now reject all data except such as are based on simultaneous observation of all three loci. This is done for the seemingly good reason that in this way all disturbing

agencies are eliminated, such as differences of temperature, age, or associated genes. But by so doing, they introduce other and much more serious disturbing agencies.

Take the case of the three genes, yellow, white and bifid, which both they and I have singled out as well illustrating the merits of our respective methods. Morgan and Bridges[3] in describing their method of constructing 'Diagram I' say. "Thus if the experiments give a cross-over value of 5 per cent for white and bifid, we say that white and bifid lie 5 units apart in the X chromosome. Other experiments show that yellow and white are about 1 unit apart, and that yellow and bifid are about 6 units apart. We can therefore construct a diagram with yellow as the zero, with white at 1, and with bifid at 6." But the Table 65 of this same publication, on the basis of which, it is explicitely stated, Diagram I was constructed, gives these distances more exactly as yellow-white, 1.1; white-bifid, 5.3; yellow-bifid, 5.5. The authors in the passage quoted ignore a considerable

TABLE 1

	FULL DATA		SELECTED DATA	
	Cross-over values	Cases	Cross-over values	Cases
Yellow-white	1.1	81,299	1.2	1,218
White-bifid	5.3	23,595	3.5	1,218
Yellow-bifid	5.5	3,681	4.7	1,218

discrepancy with these figures, since it is obvious that if the three genes are, as supposed, in a straight line, the distance yellow-bifid should equal the sum of yellow-white plus white-bifid, or 6.4 (instead of 5.5). Commenting on the actual observations in the case, I said, "Therefore bifid can lie neither above nor below yellow and white, in the line which joins them, but must lie laterally about equidistant from both." Returning to the case, Sturtevant, Bridges and Morgan now reject all but a small part of their previous data, retaining only two experiments in which all three loci were simultaneously under observation. The changed character of the data is shown in Table 1. Yellow-white is not materially affected but white-bifid is now 3.5, instead of 5.3, and yellow-bifid is 4.7, instead of 5.5. Are the new values more reliable than the old ones? So far as amount of data is concerned, they are much more liable to error through random sampling. If disturbing agencies are at work in isolated experiments, their effect is less likely to be felt in larger totals based on experi-

ments made under varied conditions. On this general ground the full data would seem to be preferable to the selected data. But let us, for the sake of argument, accept the smaller amount of selected data. What are the observational facts? In a total of 1218 flies, the gene yellow was observed to separate from the other two genes in 15 cases, and bifid was observed to separate from the other two genes in 43 cases, but white was not observed to separate from the other two genes. The 15 cases, in which yellow separates, make up 1.2% of the total, which is put down as the cross-over value between yellow and white, but in reality it is the cross-over value between yellow on one hand and the group white-bifid on the other hand. Likewise the 43 cases, which form 3.5% of the total, are put down as the cross-over value between white and bifid, but in reality they represent the cross-overs between bifid on one hand and the group yellow-white on the other. It is not certain that white with yellow attached would show the same percentage of cross-overs as without yellow attached. Indeed, in their doctrine of *interference*, the authors have long held that it would not. According to that doctrine, in case a break occurs between yellow and white, there is no chance whatever that a break will occur simultaneously in the near-by region between white and bifid, and *vice versa*, if a break occurs between bifid and white, there is no chance that a break will occur also between yellow and white. Accordingly in calculating the percentage of cross-overs for yellow-white, 15 should be deducted from the total number of cases, and in calculating the percentage of cross-overs for white-bifid, 43 should be deducted from the total, *if the principle of interference is valid*. Such correction would increase slightly the cross-over values for yellow-white and yellow-bifid, whose sum would now exceed the cross-over value given for yellow-bifid, 4.7, and would again put the three genes out of line.

It appears, then, that the authors have failed in two different attempts to establish their linear theory in the case of the three genes yellow, white and bifid. Morgan and Bridges in their equation, 'about 1' + 5 equals 'about 6,' seriously distort facts which should be very exactly stated if the linear hypothesis is to have a basis in fact as well as in fancy. The real relations, as given in their Table 65, are $1.1 + 5.3 > 5.5$. The new equation, which they now offer as a substitute for the old one, is $1.2 + 3.5 = 4.7$, which looks all right. The two halves of the equation balance, but the balance is a forced one. To obtain it two very questionable things are done. First, nearly 99% of the authoritative observations are suppressed;

secondly, the remaining observations are treated in utter disregard of the principle of 'interference' which has long been recognized by the authors and has never been repudiated by them.

But we are not without other and independent evidence of the relations between the three genes, yellow, white and bifid. Each of these has known linkage relations with other genes of the system. Pertinent facts from Table 65 of Morgan and Bridges are reproduced herewith in Table 2. They show that yellow is farther removed from vermilion, miniature and rudimentary than is either white or bifid, since the cross-over values are in every case higher. This supports Morgan's view that yellow is at the distal end of the system. If white and bifid lie in succession below yellow, white should be *farther* removed than bifid from genes lower in the system. Data are given

TABLE 2

	CROSS-OVER VALUES	CASES
Yellow-vermilion	34.5	13,271
Yellow-miniature	34.3	21,686
Yellow-rudimentary	42.9	2,563
Bifid-vermilion	31.1	2,724
Bifid-miniature	30.6	219
Bifid-rudimentary	42.7	899
Bifid-forked	42.5	306
White-vermilion	30.5	27,962
White-miniature	33.2	110,701
White-rudimentary	42.4	6,461
White-forked	45.7	3,664

for the distances to four such genes. In two cases (vermilion and rudimentary) white is nearer than bifid, in two other cases (miniature and forked) bifid is nearer than white. The more reliable cases, based on larger numbers, are those which place *white below bifid*, minimal observations 2724 and 899 respectively. The numbers which place bifid below white are 306 and 219, too small to carry much weight. We may conclude that so far as evidence given by table 65, Morgan and Bridges, is concerned, bifid is certainly as remote as white and probably more remote than white from the lower parts of the linkage system. If so, bifid cannot lie in line with yellow and white, below them in the linkage chain, as maintained by Morgan and his associates. This conclusion agrees with the relations shown in my model, but not with those shown in their Diagram I.

With reference to the reconstruction for *D. virilis*, which is very clearly three-dimensional, the authors have nothing whatever to say. It would not be known that they had seen the paper[4] in which that reconstruction is described except for a footnote at the very end of their paper, which reads "Castle concluded that the white-forked value of 45.7 used by him, is somewhat too high, which is true; but there were available to him more than 40,000 flies (Bridges, *Genetics*, 1, 1916 and Weinstein, *Ibid*, 3, 1918) giving the lower value, in contrast to the less than 4000 flies on which the high value was based." There seems to be here a veiled rebuke that I did not look outside Table 65 of Morgan and Bridges for additional data. I saw no reason for doing so since Morgan and Bridges had based their linear diagram exclusively on "the data summarized in Table 65," and it seemed to me fair to test an alternative hypothesis by the same data. Moreover I was not at that time aware that additional cases had been recorded bearing on the white-forked linkage relation. In comparing the linkage system of *D. ampelophila* with that of *D. virilis*, I mentioned quite incidentally the longer distance recorded for the former species but that my model indicated this value to be probably too high, "since the wire joining white with forked in the model is too long to harmonize fully with other linkage values given by Morgan and Bridges, the wire being curved." If my model, merely by a curved wire, was able to detect an error which would otherwise have been overlooked by me, and which it required 40,000 additional flies to prove, the reconstruction method certainly has utility. Now I have made certain predictions as to what some undetermined linkage relationships in *D. virilis* will be found to be, based on the reconstruction figured in my former paper. An experimental test of their correctness is invited. Let us taste this pudding to prove or disprove its edibility.

With reference to point (3), Morgan and his associates consider cross-over values greater than 50 possible, though not as yet observed. They are led to this conclusion by the consideration that values greater than 50 are obtained by summation of short distances, on the hypothesis of linear arrangement. Forced to a choice between non-linear arrangement and map distances greater than 50, they choose the latter, and then contend that distances greater than 50 are possible and would actually be observed except for double crossing-over. For my part, I can not conceive of a mechanism which would tie two genes *together* in such a way that they will subsequently *separate* from each other oftener than they will remain together, yet this is what the idea of cross-overs in excess of 50 per cent amounts to.

With reference to point (4), it is admitted by Morgan and his associates that "double crossing-over has no meaning, if three genes are imagined as not lying in a straight line." It is accordingly a secondary hypothesis needed to help out the hypothesis of linear arrangement, but it can not be cited as proof of that hypothesis, which must stand or fall on its own merits. I can see no reason *a priori* why two or more breaks should not occur simultaneously in different parts of a linkage system, whether linear or non-linear, but this is no evidence that, every time a particular gene separates from two others, it has done so by two independent breaks, the view necessitated by the linear hypothesis. The relation of certain observational facts to the idea of double crossing-over is correctly stated by Plough[5] in relation to the alternative hypotheses. On a non-linear hypothesis, temperature affects "long chromosomal distances" (high cross-over values) less than small ones; on the linear hypothesis, temperature acts by changing the frequency of double crossing-over. This is no proof of either hypothesis, but a statement of fact in terms of each.

[1] Sturtevant, A. H., Bridges, C. B., and Morgan, T. H., these PROCEEDINGS, **5**, 1919, (168).
[2] Castle, W. E., these PROCEEDINGS, **5**, 1919, (25).
[3] Morgan, T. H., and Bridges, C. B., "Sex-linked inheritance in Drosophila," *Carnegie Inst., Washington Publ.*, No. 237, May 8, 1916.
[4] Castle, W. E., these PROCEEDINGS, **5**, 1919, (32).
[5] Plough, H. H., these PROCEEDINGS, **5**, 1919, (167).

ON VARIATION IN TARTARY BUCKWHEAT, FAGOPYRUM TATARICUM (L.) GAERTN.

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Introductory.—From the morpho-genetic point of view the manifestation of dimorphism in certain races of plants—the so called ever-sporting varieties—presents a very interesting problem. The remarkable feature of these races is the constancy with which the two diverging forms of the same organ are transmitted in ever-sporting fashion: no breeding method has, as yet, been conceived by which, for instance, certain variegated types of plants or certain strains of Matthiola, could be induced to breed true. These races appear as compound forms ever-transmitting the potentialities of the two component types.

Dimorphism manifests itself in two externally different forms. The different characteristics may appear simultaneously distributed in the organs of the same individual as in *Trifolium pratense quinquefolium* De Vries or in *Veronica agrestis;* in another group of plants each individual of the race may display only one of the dimorphic characters as in the case of certain strains of Matthiola, Antirrhinum, *Dipsacus sylvestris torsus*, etc.

In interpreting these phenomena, De Vries whose investigations involved a great abundance of material, assumes the peculiar behavior of these races to be due to the interaction of two "antagonistic, mutually exclusive characters." The operation of these two contending characters within the individual leads to the formation of two distinct groups of plants, the half-races and the middle races or ever-sporting varieties. Opposed to this interpretation is the view held by certain writers who consider the ever-sporting nature of many of these races as mere somatic variations and relegate them into the group of non-heritable modifications.

More recently, however, some of the ever-sporting types in plants as well as in animals have been subjected to a genetic analysis and their peculiar mode of inheritance has been explained on Mendelian grounds.

The purpose of the present communication is to record the results of a study on a highly variable, ever-sporting race which I have discovered in *Fagopyrum tataricum* Gaertn. (*Polygonum tataricum* Linn.). In the course of observations on this race my attention was chiefly devoted to the study of variation and transmission of the external characters in an endeavor first to establish by direct experiment the behavior of this race under different conditions before attempting an analysis of the underlying genetic causes.

The full account of this investigation will be published in *Genetics*.

Material and experimental methods.—The race with which the present account is concerned originated from commercial fruits of Fagopyrum tataricum, Tartary Buckwheat, which had grown in Maine. In a population of several hundreds of plants, one plant was found to be distinguished by a particularly high degree of variability in the structure of its flowers. This plant was selected as a starting point of a strict pedigree culture, and since its isolation in 1916 five generations have been grown. The study of floral variations of this race involved the examination of more than 57,000 flowers and fruits.

The manifestation of variations of this race was studied under different conditions of environment. The cultures grew in pots under greenhouse

conditions and in the garden. Two greenhouses were used whose conditions differed greatly, notably with respect to humidity and temperature. In one of the greenhouses prevailed what might be called a moist and hot condition, the temperature varying only slightly, from 75°F. during the day to 70°F. at night. In the other greenhouse where the cultures grew in the summer time no artificial heat was used, the temperature following the natural daily amplitude. The air in this greenhouse was quite dry.

In connection with the study of the effect of nutrition and starvation upon the teratological development of this race, the cultures were grown in different nutritional media comprising rich composted or fertilized soil, ordinary soil, sand, and gravel.

Observations and results.—The variations here considered occur in the gynoecium, the perigone, and the vegetative organs of this race. Most of these variations have hitherto not been recorded for Fagopyrum tataricum.

The variations in the gynoecium are characterized by the production of supernumerary carpels. The number of carpels per pistil was found to vary from 3 up as high as 25. Under ordinary conditions of growth the number of flowers with normal gynoecia predominates over or equals the number of flowers with abnormal gynoecia. Under conditions favoring the development of abnormal flowers the variation is bilateral, and can be represented by a curve the apex of which is formed by the abnormal four-carpelled flowers. The frequency distribution of flowers with respect to number of carpels is given in table 1.

From table 1 it will be noted that the frequency distribution of flowers with abnormal gynoecium decreases as the number of aberrant carpels per pistil increases.

Associated with the abnormal gynoecia are abnormal perigones with a varying number of segments ranging from the normal number of 5 as high as 18. The favorable conditions capable of transforming the unilateral variation of the gynoecia into a bilateral one, failed to affect the perigones in the same manner. The variation in the number of perigone leaves remained unilateral with the frequency of the normal, five-parted perigone forming the apex of the skew curve (table 2).

The frequency of the normal, five-parted perigones decreases as the number of carpels per pistil increases. The relationship between the number of carpels and perigone leaves is illustrated in table 3.

All descendants of the ever-sporting race were found to reproduce the ever-sporting type of the mother plant regardless of whether they originated from normal or abnormal fruits of the parent.

TABLE 1

ACTUAL AND PERCENTAGE FREQUENCIES OF NUMBER OF FLOWERS WITH REGARD TO NUMBER OF CARPELS

PLANT NUMBER		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		SYNANTHIES		TOTAL
		Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	
Pot 36	1	78	17.69	320	72.56	27	6.12	5	1.13	2	0.45	1	0.23	1	0.23	2	0.45	1	0.23					1	0.23											3	0.68	441
	2	49	14.41	249	73.24	17	5.00	10	2.94	1	0.29	3	0.82			1	0.29							1	0.29											9	2.65	340
	3	119	19.97	389	65.27	46	7.72	10	1.69	3	0.50	10	1.68	3	0.50	5	0.84			1	0.17														10	1.68	596
Pot 37	4	130	16.62	520	67.01	66	8.51	14	1.80	5	0.64	10	1.29	10	1.29	5	0.64			2	0.26							1	0.13							13	1.68	776
	5	136	20.80	430	65.60	51	7.80	8	1.22	6	0.92	7	1.07	1	0.15	3	0.46																			12	1.83	654
	6	150	21.08	488	68.54	49	6.88	7	0.98	3	0.42	2	0.28	2	0.28	4	0.56																			7	0.98	712
Pot 39	7	127	15.05	572	67.77	67	7.94	24	2.83	9	1.07	7	0.83	4	0.47	8	0.95			8	0.95	2	0.24										1	0.12	15	1.78	844
	8	190	17.48	719	66.51	101	9.34	15	1.39	6	0.56	7	0.65	6	0.56	13	1.20	3	0.28	5	0.46	1	0.09	1	0.09							1	0.09			13	1.20	1081
Total..		979		3687		424		93		35		47		27		41		4		16		3		3				1				1		1		82		5444
Percentage..			17.98		67.73		7.79		1.71		0.64		0.86		0.49		0.75		0.07		0.29		0.06		0.06				0.02				0.02		0.02		1.50	

TABLE 2

ACTUAL AND PERCENTAGE FREQUENCIES OF NUMBER OF FLOWERS WITH RESPECT TO NUMBER OF PERIGONE LEAVES

PLANT NUMBER		NUMBER OF PERIGONE LEAVES																TOTAL
		5		6		7		8		9		10		11		12		
		Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	
Pot 36	1	308	70.32	105	23.97	18	4.11	4	0.91	2	0.46	1	0.23					438
	2	214	64.65	89	26.89	21	6.34	5	1.51	1	0.30	1	0.30					331
	3	410	69.97	141	24.06	23	3.92	7	1.19	3	0.51	2	0.34					586
Pot 37	4	541	70.90	162	21.23	37	4.85	14	1.83	1	0.13	7	0.92			1	0.13	763
	5	447	69.63	150	23.86	29	4.52	11	1.71			5	0.78					642
	6	538	76.31	131	18.58	28	3.98	5	0.71	2	0.28	1	0.14					705
Pot 39	7	604	72.86	169	20.39	31	3.74	13	1.57	7	0.84	5	0.60					829
	8	784	73.41	212	19.85	44	4.12	10	0.94	4	0.37	10	0.94	1	0.09	3	0.28	1068
Total		3846		1159		231		69		20		32		1		4		5362
Percentage		71.72		21.62		4.31		1.29		0.37		0.59		0.02		0.08		

TABLE 3

PERCENTAGE FREQUENCIES SHOWING RELATION BETWEEN NUMBER OF CARPELS AND NUMBER OF PERIGONE LEAVES

NUMBER OF PERIGONE LEAVES	NUMBER OF CARPELS																
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	89.68	71.30	58.96	35.48	54.29	42.35	48.15	36.59	25.00	56.25	33.33						
6	8.78	25.33	24.76	26.88	2.85	14.89	3.70										
7	1.33	3.09	14.15	23.66	11.43					6.25							
8	0.20	0.27	1.88	10.75	14.29	31.91	3.70	24.39	25.00		33.33	33.33					
9			0.24	3.23	17.14	2.13	18.52	7.32	25.00								100
10						8.51	25.93	26.83	25.00	31.25	33.33	33.33					
11								2.44									
12								2.44		6.25		33.33				100	
Total...	99.99	99.99	99.99	100.00	100.00	99.99	100.00	100.00	100.00	100.00	99.99	99.99				100	100

The ratio between the normal and abnormal flowers was found to be a function of the environment. Under a given set of environmental conditions this ratio as well as the relationship between the different forms of abnormal flowers *inter se* is constant to a very marked degree.

Selection carried out for five years had no visible effect upon the type and range of floral variations of this race. The ever-sporting strain after isolation at once displayed the highest degree of abnormality ever reached in the subsequent generations under similar conditions of environment.

Under conditions controlling the intensity of abnormal development, optimum nutrition or starvation, while affecting the habit of the plant, appeared to have no effect upon the degree of manifestation of floral abnormalities. The evidence from the study of this race under different conditions of environment points to high humidity and temperature as the factors favoring the expression of abnormality. Under conditions void of optimum humidity and temperature, the influence of starvation and lack of water upon the degree of abnormal development was noticeable.

The results of a study of the frequency distribution of the different types of flowers upon the plant point to the existence of a definite region on the plant in which the tendency to vary and proliferate is most pronounced. Considering the plant as a whole, this region is confined to the basal, differentiated parts of the plant. The frequency distribution given in table 4 shows that the first three branches on the main stem from below, especially the second one, mark the seat of greatest abnormal development while the racemes in the axils of the 4th, 5th, and 6th branch show a low degree of variability as well as the lowest absolute number of flowers.

Similar but more marked differences prevail in the individual branches of the second and third order. Here it is again the buds in the axils of the second leaf and in the basal region of the terminal raceme that show the greatest relative number of abnormal flowers as well as the greatest range of variability as measured by the frequency occurrence of the most aberrant variants.

Relative to the frequency occurrence of the different types of flowers at different periods of the flowering season, under the conditions prevailing in the greenhouse the first and second week of the flowering season mark the lowest relative production of abnormal flowers, after which a marked increase in the output of abnormalities follows when the secondary and tertiary branches begin to develop their flowers. Towards the end of the flowering season the upper regions of the plants produced only

TABLE 4

ACTUAL AND PERCENTAGE FREQUENCY DISTRIBUTIONS OF FLOWERS BORNE BY EACH ORGAN OF EACH PLANT, WITH RESPECT TO NUMBER OF CARPELS

POSITION OF FLOWERS	NUMBER OF CARPELS																																							
	3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		Synanthies		Total
	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	Actual	Percentage	
In axils of Cotyledons	97	16.33	389	65.71	60	10.14	15	2.53	3	0.51	5	0.84	3	0.58	4	0.68	1	0.17	5	0.84							1	0.17							9	1.52	592
On Branch 1	234	18.75	829	66.43	105	8.41	21	1.68	8	0.64	19	1.52	6	0.48	12	0.96															1	0.08			13	1.04	1248
On Branch 2	245	18.39	880	66.07	98	7.36	25	1.88	14	1.05	8	0.60	4	0.30	15	1.13	2	0.15	5	0.38	2	0.15	2	0.15									1	0.15	31	2.33	1332
On Branch 3	242	17.60	927	67.42	111	8.00	25	1.82	8	0.58	13	0.95	13	0.95	7	0.51	1	0.07	6	0.44	1	0.07													21	1.53	1375
On raceme in axil of leaf 4	37	16.30	167	73.57	15	6.61	2	0.88	1	0.44					2	0.88							1	0.44											2	0.88	227
On raceme in axil of leaf 5	20	15.75	93	73.23	11	8.66	1	0.78																											2	1.57	127
On raceme in axil of leaf 6	38	19.10	144	72.36	11	5.93	2	1.01	1	0.50					1	0.50																			2	1.01	199
Terminal raceme	66	19.19	258	75.00	13	3.72	2	0.58			2	0.58	1	0.29																					2	0.58	344
Total	979		3687		424		93		35		47		27		41		4		16		3		3				1				1		1		82		5444

very few flowers while the lower differentiated parts of the plants sustained their flower production to the end of the flowering season.

Floral prolifications in the form of various types of synanthous flowers, often giving rise to syncarpous fruits, were found to be transmitted from generation to generation in fairly constant proportions under given conditions of environment.

The teratological development of the vegetative organs appeared in the form of more or less developed fasciations. Fasciated branches were first discovered on the plants of the fourth generation grown under crowded conditions, in pots. In the next generation, under favorable conditions of nutrition, the fasciated character asserted itself in a manner typical of the ever-sporting races the fasciations being reproduced by half of the progeny.

THE EFFECT OF MILLING ON THE DIGESTIBILITY OF GRAHAM FLOUR

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Office of Home Economics, U. S. Department of Agriculture

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The bulk of wheat used for flour in this country is made into patent flour which contains about 72% of the wheat kernel. Entire or whole-wheat flour which contains 85% of the wheat and true Graham flour which contains 100% are also well-known commodities.

The digestibility of patent flour is considerably higher than that of entire-wheat or Graham flours. An average[1] of 31 tests by other investigators with patent flour shows that the coefficient of digestibility for the protein is 88.1% and for carbohydrate 95.7%, while an average of 43 as yet unpublished tests made in this laboratory[2] on patent flour gave the coefficient 89.5% for the digestibility of protein and 99.9% for that of carbohydrate. An average[1] of 23 tests of the digestibility of entire-wheat flour (85% extraction) gave the coefficient 81.9% for the protein and 94.0% for the carbohydrate while an average[2] of 16 tests on similar flour by this office[2] gave the coefficient 87.1% for the protein and 98.3% for the carbohydrate. The average[1] of 24 tests on true Graham flour was 76.9% for protein and 90.1% for carbohydrate and an average of 33 experiments on the same flour by this office[2] gave the value 84.2% for protein and 94.4% for carbohydrate.

It has been a question as to how the milling of Graham flour effects its digestibility. Wheat milled by different processes gives bran particles varying in size from the very small ones obtained with a burr-stone mill to very large ones with a roller mill. The method of milling also effects the extent to which the walls of the aleurone cells are broken or weakened. These, if intact, prevent the digestion of their contents, and so the more they are broken the more completely are the nutrients of the flour digested. Lapicque and Liacre[3] found that kneading the bread broke the aleurone cell walls at points weakened by the milling process. Obviously, the method of milling would affect the extent to which the walls of the aleurone cells would be weakened. The experiments here reported were undertaken to determine how different methods of milling effected the digestibility of Graham flour.

The flours were all made from a single lot of Minnesota spring wheat secured through the courtesy of the Plant Chemical Laboratory of the Bureau of Chemistry. Portions of the wheat were ground by the following methods: (1) Small laboratory roller mill, (2) commercial roller mill, (3) burr-stone mill, (4) steel-burr mill, (5) steel attrition mill.

The portions of flour milled on the laboratory roller-mill, the burr-stone mill, and the steel-burr mill were prepared on the mills of the Plant Chemical Laboratory, Bureau of Chemistry. The commercial roller-mill flour and the attrition-mill flour were prepared by two commercial concerns.

As was the case in many other tests in this laboratory, the flour was fed in the form of a simple 'quick bread,' which was baked each day. A little ginger not only added to the palatability but masked any differences between the breads in the different tests. The following recipe was used:

Experimental bread

15 cups flour	3¾ teaspoons salt
3¾ teaspoons soda	5 teaspoons ginger
1¾ cups molasses	1 scant cup lard

1⅞ quarts hot water

The lard was added to the hot water, this mixture was added to the other ingredients. This was thoroughly mixed and baked for 1½ hours.

With a generous portion of the bread a simple basal ration of fruit (oranges), butter, and sugar, with coffee or tea without cream, if desired, was eaten. The tests were of three days or nine meals duration. The separation of the feces, analyses, etc., were those usually followed.

The subjects were young men, twenty to thirty years old, students in a local university, in good physical condition, familiar with this type of work, and entirely trustworthy.

Granulation tests made with the different flours showed the following percentages remaining on each sieve.

Results of granulation tests with different Graham flours

KIND OF MILL USED	PER CENT ON 20 SIEVE	PER CENT ON 40 SIEVE.	PER CENT ON 70 SIEVE	PER CENT ON 90 SIEVE	PER CENT ON 100 SIEVE	PER CENT THROUGH 100 SIEVE
Laboratory roller mill	18.0	36.6	21.8	9.0	4.6	8.2
Commercial roller mill	10.6	20.6	23.8	14.2	7.0	22.8
Steel-burr mill	4.2	23.8	18.0	13.2	8.4	32.4
Attrition mill	0.8	23.0	17.6	13.4	8.8	36.6
Stone-burr mill	3.2	13.4	12.2	19.4	11.6	39.2

It will be noted that the flour from the laboratory roller mill was the coarsest, while the stone-burr mill gave the flour of the greatest fineness. In this table and those that follow the flours are given in the order of their size from the coarsest to the finest.

The condensed results of the experiments appear in the tables which follow:

Average amount of Graham bread and total food eaten per man per day

	WEIGHT	CONSTITUENTS OF FOODS				
		Water	Protein	Fat	Carbohydrate	Ash
	grams	*grams*	*grams*	*grams*	*grams*	*grams*
Laboratory roller-mill flour						
Bread	475.9	178.2	32.4	31.1	224.5	9.7
Total food	978.4	450.2	35.5	88.8	390.7	13.2
Commercial roller-mill flour						
Bread	487.9	150.8	37.2	28.3	260.8	10.9
Total food	1,024.0	465.9	40.7	89.6	412.8	14.8
Steel-burr mill flour						
Bread	527.0	164.3	44.5	31.4	274.4	12.3
Total food	1,037.0	440.2	47.8	104.9	427.6	16.5
Attrition mill flour						
Bread	457.3	143.9	35.7	29.0	238.3	10.4
Total food	907.2	399.4	38.7	84.6	370.7	13.9
Stone-burr mill flour						
Bread	534.8	179.7	39.5	27.5	275.8	12.2
Total food	1,046.6	459.2	42.8	99.2	429.1	16.4

Average digestibility of Graham flours milled by different methods

KIND OF FLOUR	NUMBER OF EXPERIMENTS	DIGESTIBILITY OF ENTIRE RATION				ESTIMATED DIGESTIBILITY OF PROTEIN ALONE	ESTIMATED DIGESTIBILITY OF CARBOHYDRATE ALONE
		Protein	Fat	Carbohydrate	Ash		
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Laboratory roller mill flour	5	72.1	94.4	96.0	70.1	70.7	95.3
Commercial roller mill flour	5	72.1	95.6	95.4	67.6	70.4	93.8
Steel-burr mill flour	4	79.2	95.0	96.1	73.8	78.5	95.3
Attrition mill flour	3	75.5	92.9	96.1	69.7	74.5	95.4
Stone-burr mill flour	4	79.2	96.5	96.6	78.4	78.2	96.8

The subjects in reports of their condition mentioned no discomfort. They did, however, speak of a somewhat laxative effect but noted no difference in this respect between the flours in which the bran was finely ground and those in which it was coarse.

The amount of protein digested varied from about 70% in the roller mill flours in which the particles of bran were the largest to 78% in the stone-burr mill and steel-burr mill flours in which the bran particles were much finer. This is what we should expect for it has been shown that the bran protein[1] is about 44% digested in the case of fine bran while it is only 28% digested in coarse bran.

The coefficient of digestibility for carbohydrate varied from 93.4% in the coarse roller mill flour to 96.8% in the stone-burr mill flour. The estimated digestibility of the protein and carbohydrate represent the digestibility of the protein and carbohydrate of the flour alone after allowance has been made for the undigested residues of the accessory food. Possibly because of the kind of wheat used, the figures for protein are somewhat lower than corresponding figures in other digestion experiments on 100% flour. Nevertheless, since those here studied are all from the same lot of wheat they are directly comparable with one another. The finer the particles, the more completely the protein was absorbed while the absorption of carbohydrate varied only slightly.

In conclusion, it is fairly safe to say that the finer a bran-containing flour is ground, the more completely it is utilized by the human body.

[1] *Washington, U. S. Dept. Agric. Bull.*, No. 751, 1919, (pp. 20).

[2] Unpublished experiments.

[3] Lapicque, L., and Liacre, A., *C. R. Soc. Biol., Paris*, 81, 1918, No. 5, (pp. 217–220).

THE OZONE FORM OF HYDROGEN

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In spite of its having only a single valence bond, hydrogen seems to form an active variety bearing the same relation to ordinary hydrogen that ozone bears to oxygen. The chemical activity of this form of hydrogen is not attributable to single free atoms, since the characteristics of the atomic form are well known, and different from those of this ozone form.

Professor Sir J. J. Thomson,[1] in working with positive rays in 1912, showed the existence in a hydrogen discharge tube of particles with a molecular weight of 3. He gave the tentative symbol of X_3 to this material, and investigated its chemical properties in some detail. He found that it combines with oxygen under the action of light. It is also destroyed by sparking with oxygen, as well as by being heated in a quartz tube with copper oxide. In the absence of oxygen the gas could be heated to a high temperature without destruction. Attempts to obtain spectroscopic evidence of the new form of hydrogen failed, only the usual spectrum being evident.

An investigation begun in 1914 with the co-operation of Professor William Duane[2] showed that hydrogen becomes chemically active under the influence of alpha rays from radium emanation, and that when this active variety is formed there is a distinct contraction in volume. The active hydrogen attacks sulphur, forming hydrogen sulphide. This reaction is the simplest test for the presence of the active modification: The hydrogen is activated by the rays; it is allowed to pass over sulfur, and then passes over a strip of filter paper moistened with lead acetate which it blackens, due to the hydrogen sulphide present. Other reactions are equally simple and characteristic. It reduces neutral permanganate solution to give a precipitate of manganese dioxide; acid permanganate is entirely decolorized, giving a manganous salt. Arsenic is reduced to arsine; phosphorus gives phosphine. There is some action even on mercury, giving a lustrous yellow compound, presumably a hydride, which decomposes on heating. This activity is not due to the presence of charged molecules or ions, as these can be completely removed by an electrostatic field of a thousand volts per centimeter without destroying the chemical activity of the gas.

The active modification is unstable, and must be allowed to react with the oxidizing substance within three or four minutes of the time of its formation. Here again its properties are those to be expected from an ozone form. Passage of the gas through a tube immersed in liquid air destroys its activity either by condensing the active variety which thus has a boiling point very much higher than that of ordinary hydrogen, or by causing its disintegration into ordinary H_2.

A molecule larger than H_2 is indicated by various facts. The purest obtainable hydrogen contracts when under the influence of alpha rays. This has recently been confirmed by Lind,[3] working with large quantities of radium emanation. Usher,[4] working in Ramsay's Laboratory in 1909, observed the same effect, but attributed the loss of volume to the projection of hydrogen molecules into the glass walls of the retaining vessel when bombarded by alpha rays, although the volume of hydrogen lost was larger than the number of alpha rays would permit, and although he was also unable to regain an adequate volume of hydrogen when the glass walls were pulverized and heated.

The second line of evidence results from Langmuir's[5] preparation of an active form of hydrogen which is probably monoatomic. This hydrogen is present in an electric light bulb when the filament is heated to a high temperature, and is undoubtedly a consequence of the dissociation of hydrogen molecules at the high temperature of the filament. When the pressure in the bulb is very low this atomic form of hydrogen forms a layer on the inner surface of the glass wall, and although thus attached, is chemically active. It reacts rapidly with phosphorus vapor, for instance. It has two marked characteristics which distinguish it from the ozone form; namely, that it will not pass through a plug of glass wool, being adsorbed strongly by this substance; and secondly, that it does not exist except at the very highest vacua. When more hydrogen is admitted into the bulb than is necessary to make a layer one atom deep on the glass wall, the amount of active hydrogen is much reduced, the excess molecules seeming to react with the active atoms. The ozone form of hydrogen, on the other hand, will pass through long layers of glass wool and exists for some time at atmospheric pressure.

The third and direct evidence that this hydrogen is polyatomic is found in the work of Sir J. J. Thomson and of Dempster,[6] both of whom made use of the method of positive ray analysis to determine the constituents of a gaseous mixture in the presence of an electric discharge at high vacuum. The photographic method of Thomson and the electrical measurement method of Dempster both show the presence of

considerable quantities of H_3 in an H_2 tube. At pressures of 0.05 mm., indeed, Dempster has shown that H_3 predominates.

Very recent work has shown that this active hydrogen is present in large quantities in any ordinary hydrogen discharge tube. A Geissler tube under a pressure as high as 6 cm. contains the ozone hydrogen. If hydrogen is passed continuously through such a tube and is then allowed to react with sulfur a lead acetate paper is decidedly blackened in the course of two or three minutes. Potassium permanganate is decolorized with equal speed. This is an effective lecture experiment. No ions are present in this hydrogen, as can readily be shown by passing the gas through a sensitive emanation electroscope. When this instrument is sensitive enough to detect 10-12 Curie of radium emanation with ease, the electroscope leaf remains perfectly steady though the active hydrogen is passed through for hours. The activity is therefore due to molecules.

The mechanism by which these larger and unstable molecules are formed is still obscure. In the case of their formation under the action of alpha rays they may be the product of the bombardment of ordinary hydrogen molecules by means of the swift and very energetic alpha particles. A hydrogen atom thus projected by bombardment into an ordinary hydrogen molecule may remain there in the metastable condition of a triatomic molecule. The formation of this variety of hydrogen, however, in the cathode ray discharge tube, where the only bombardment is by a stream of electrons, indicates that probably nothing more than ionization is necessary. The most plausible hypothesis is that the ions collect about them a cluster of molecules, forming a so-called large ion, and that the valence bonds in such a group are so disintegrated that the cluster breaks down with the formation of various types of fragments, among them H_3 as well as H_2. Cluster ions are undoubtedly present in such a tube, though their quantity is hard to estimate. Dempster has shown, however, that at low pressures both H_3 and H_2 are present in large quantities, with H_3 predominating in certain ranges of pressure. Still more information on the mechanism of the formation of this type of molecule would be obtainable from a study of the action of very short wave-length light on hydrogen. The Schumann region of the spectrum is absorbed by hydrogen, and the ionization or molecule shattering that probably then occurs may also give rise to this ozone form. This phase of the question is now being investigated.

The existence of such a molecule as H_3 does not accord with the present theories of valence. The univalence of hydrogen is the basis of the

present theory, and no diagram of H_3 can be made without in one manner or another splitting the single unitary valence bonds into fractions, as for instance is possible with the conception of J. Stark. H_3 has been shown to be consistent with Bohr's model of the hydrogen atom. But the chemist will require a more definite picture to show the structure of this compound and to reconcile its very ordinary existence and properties with his theoretical conceptions. Hydrogen seems no different from oxygen in this regard. Indeed, it is probably only the injunction due to the valence theory which has prevented the observation of this variety of hydrogen at a much earlier time than the present.

[1] *Rays of Positive Electricity*, Longmans, 1913.
[2] Duane and Wendt, *Ithaca*, *Physic. Rev.* **10**, 1917, (116-128).
[3] S. C. Lind, *Easton, Pa.*, *J. Amer. Chem. Soc.*, **41**, 1919, (545).
[4] F. L. Usher, *London*, *J. Chem. Soc.*, **97**, 1909, (400).
[5] Irving Langmuir, *J. Amer. Chem. Soc.*, **34**, 1912, (860, 1310); **36**, 1914, (1708); **37**, 1915, (417).
[6] A. J. Dempster, *London*, *Phil. Mag.*, **31**, 1916, (438-43).

A VAPOR-FREE VACUUM SEAL

By A. H. Pfund

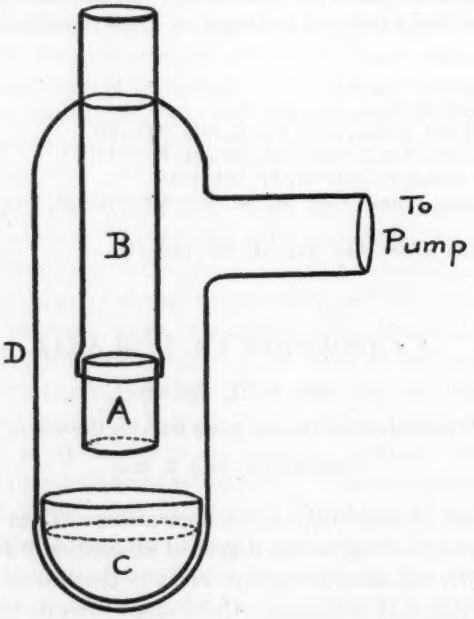
Department of Physics, Johns Hopkins University

Communicated by J. S. Ames

The behavior of stop-cocks in vacuum manipulations is, as a rule, quite satisfactory so long as the degree of exhaustion is not very high. However, when the utmost vacuum must be reached and maintained, the ordinary stop-cock is useless. Quite apart from its tendency either to leak or to fill up with grease, its main defects are: 1. Evaporation of volatile constituents of the grease into the evacuated chamber. 2. Comparatively small diameter of opening. Another element has been brought to light by Shrader who has recently shown (*Physical Review*, *Ithaca*, June, 1919, p. 434) that the gases liberated from the seal, when a glass bulb is sealed off the pump, increase the pressure several hundred per cent over that which had existed previously. An attempt has been made to overcome these difficulties by designing a vacuum seal of the type shown in sketch.

The apparatus takes the form of the well-known trap, slightly modified. A hollow cylinder of platinum (A), either seamless or made

of foil soldered with gold, is fused to the lower end of the central glass tube (B). The outer surface of the platinum is first tinned and is then coated with a thin layer of low melting point solder, such as Wood's metal or equal parts of ordinary solder and bismuth. An iron cup (C), which fits into the tube D rather snugly, is filled to a depth of about 5 mm. with this solder. This system must receive the usual baking treatment to drive off absorbed gases. In order to effect a seal, the lower half of the bulb (D) is immersed in hot water or is gently heated



with a bunsen burner until the solder melts. Then the cup is raised by means of an electro-magnet until the platinum tube is imbedded in the solder. The seal is tight as soon as solidification has taken place. In order to re-open the seal, the solder is melted and the cup lowered. It is obvious that this device may be used to seal off a piece of apparatus either temporarily or permanently.

Experience has shown that a seal of the above type possesses the following advantages:

1. It is tight and vapor free. 2. The openings may be made large. 3. Apparatus which has become gassy may be re-exhausted without admitting air—as is unavoidable in present practice.

NATIONAL RESEARCH COUNCIL

MINUTES OF JOINT MEETING OF THE EXECUTIVE BOARD OF THE NATIONAL RESEARCH COUNCIL WITH THE COUNCIL OF THE NATIONAL ACADEMY OF SCIENCES

AT THE NATIONAL RESEARCH COUNCIL BUILDING, JUNE 24, 1919, AT 9.30 A.M.

Present: Messrs. Bancroft, Clevenger, Dunn, Hussey, Leuschner, Mathews, McClung, Merriam, Ransome,* Stratton, Walcott* Washburn, Woodward.

Mr. Walcott in the chair during the transaction of the business of the Council of the Academy.

Mr. Merriam in the chair during the transaction of the business of the National Research Council.

The minutes of the joint meeting of the Executive Board of the National Research Council with the Council of the National Academy of Sciences of May 27 and minutes of the meeting of the Executive Board of the National Reseach Council of June 10 were approved as circulated.

The President of the National Academy of Sciences presented the following resolution which was passed by the Carnegie Corporation of New York on June 3, 1919, making provision to cover expenses of the National Research Council during the coming year:

RESOLVED, That, pursuant to Paragraph 3 of the resolution recording action taken at the special meeting of the Board of Trustees held March 28, 1919, the sum of One Hundred Thousand Dollars ($100,000) be and it hereby is appropriated to the National Academy of Sciences for the use of the National Research Council for the year beginning July 1, 1919; and that the Treasurer be and he hereby is authorized to make payments as needed to the extent of $100,000 on certificates of the Chairman of the National Academy of Sciences and the Chairman of the National Research Council.

Moved: That the Executive Board of the National Research Council go on record as appreciating the recognition by the Carnegie Corporation of New York of the work which it is accomplishing by appropriating the sum of $100,000 for its use for the year beginning July 1, 1919. (*Adopted.*)

To further the plans for a new building for the National Academy of Sciences and the National Research Council, it was

Moved: That the President of the National Academy of Sciences be authorized to enlarge the functions and personnel of the present Committee on Building Plans so that the Committee shall be constituted hereafter as follows: Messrs. Geo. E. Hale (Chairman), J. R. Angell, Gano Dunn, J. C. Merriam, R. A. Millikan, A. A. Noyes, C. D. Walcott, with Mr. H. S. Pritchett in an advisory capacity. (*Adopted.*)

Messrs. Dunn and Leuschner verbally submitted amendments to the Articles of Organization of the National Research Council providing for the continua-

* Members of the Council of the National Academy of Sciences.

tion of retired Chairmen of the Council as members of the Executive Board and for the appointment of Chairmen of the Divisions of General Relations.

Moved: That Messrs. Dunn and Leuschner be requested to formulate suitable amendments to the Articles of Organization of the National Research Council providing for the continuation of retired Chairmen of the Council as members of the Executive Board, and for the appointment of Chairmen of the Divisions of General Relations. (*Adopted.*)

Mr. Leuschner, Acting Chairman of the Division of Physical Sciences, submitted the following resolution of the American Section of the International Astronomical Union:

RESOLVED, That it be the sense of the American Section of the International Astronomical Union that the Executive Board of the National Research Council be requested to guarantee a sum, not to exceed $1500, to cover the American Share of the Administrative expenses of the International Astronomical Union.

Moved: That the Executive Board of the National Research Council underwrite the share of the United States of the administrative expenses of the International Research Council and of its affiliated Unions to an amount not to exceed $5000 and that this item be provided for in the provisional budget for 1919–20. (*Adopted.*)

The Chairman of the National Research Council presented the following letter from the Rockefeller Foundation, appropriating the sum of $20,000 to meet the expenses involved in conferences of special sub-committees on research subjects of the Division of Physical Sciences.

THE ROCKEFELLER FOUNDATION

June 20, 1919.

My Dear Mr. Merriam:

I have the honor to inform you that at a meeting of the Executive Committee of the Rockefeller Foundation held June 16, 1919, the following resolution was adopted:

RESOLVED: That the sum of Twenty thousand dollars ($20,000) be, and it is hereby, appropriated to the National Research Council for the Division of Physical Sciences, of which so much as may be necessary shall be used to defray the necessary travelling and other expenses involved in conferences of the sub-committees of that division during the year 1919.

Very truly yours,

EDWIN R. EMBREE, *Secretary.*

Moved: That the Chairman of the National Research Council express in behalf of the Executive Board its appreciation of the interest which the Rockefeller Foundation has shown in the research work of the Division of Physical Sciences by appropriating the sum of $20,000 to meet the expenses involved in conferences of special sub-committees on research subjects of that Division. (*Adopted.*)

The Chairman of the National Research Council announced the following Committee on Publication of 'The Inquiry' Results; authorized June 10, 1919; Messrs. C. D. Walcott (Chairman), James R. Angell, E. B. Mathews.

The Chairman raised the question of continuing the status and titles of the scientific attachés at the American embassies in Europe from July 1 to September 30, 1919.

Moved: That the necessary steps be taken by the President of the National Academy of Sciences to continue the status and titles of the scientific attaches at the American embassies in Europe from July 1 to September 30, 1919. (*Adopted.*)

In accordance with the resolution adopted at the meeting of the Interim Committee of March 25, 1919, providing that a committee on Scientific Men as Reserve Officers in the Reorganized Army be appointed by the Chairman to formulate plans for advising the Army and Navy in the reorganization of their research activities at the close of the war, Mr. Walcott presented the following resolution in behalf of the Committee (Messrs. Walcott, Chairman, Mathews, Leuschner):

WHEREAS, the present war has shown the necessity for scientific experts trained in lines not essentially military, and that in times of peace many serviceable men occupy civil positions from which they cannot be drawn by the ordinary attractions of military service, and

WHEREAS, the development of a corps of scientific experts for military purposes in times of emergency involves great loss of time in finding and organizing suitably trained experts to apply their expert knowledge to military problems

The National Research Council respectfully suggests and recommends that in the reorganization of the Army and Navy suitable provision be made for a number of reserve officers who may become, during time of peace, familiar with the military applications of their special knowledge and in case of war serve as a nucleus for temporarily enlarged forces in their special lines. Such reserve officers should be primarily scientific experts in physics, chemistry, geography, biology, geology, psychology, mathematics, astronomy, engineering, medicine, and such other sciences as may be appropriated.

They should be relieved, if necessary, from the requiremet of previous military training, and from annual active military service, and be required to give the equivalent time to the investigation in their special fields of problems of military application.

In order that no hardship may be imposed upon regular officers through service under the direction of specialists with lower military rank such reserve officers should have a rating comparable to their work.

Moved: That the foregoing resolution presented by the Committee on Scientific Men as Reserve Officers in the Reorganized Army, be approved. (*Adopted.*)

On recommendation of the Chairman, it was

Moved: That a committee be appointed for the consideration of all requests for the financial support of the objects of the National Research Council and for the unification of plans for securing financial support, with power until the next meeting of the Executive Board. (*Adopted.*)

Appointed: Messrs. J. R. Angell (Chairman), John C. Carty, Gano Dunn, Geo. F. Hale, H. E. Howe, Vernon Kellogg, and J. C. Merriam.

Moved: That the President of the National Academy of Sciences request the Department of State to detail some official already in Europe to attend the meetings at Brussels and assist the delegates to the International Research Council with advice on diplomatic matters. (*Adopted.*)

On recommendation of the Committee on Delegates, Messrs. Walcott, Leuschner, Yerkes, to the international conferences to be held at Brussels July, 1919, it was

Moved: That the following be approved as possible delegates to the meetings of the International Research Council at Brussels July 1919; Major J. L. Coolidge, nominated by the American Mathematical Society, and Dr. C. L. Gibson, nominated by the Division of Medical Sciences. (*Adopted.*)

Mr. Leuschner, Acting Chairman of the Division of Physical Sciences, presented a request from the American Section of the International Geophysical Union that surveys of international geophysical organizations prepared by members of the Section for the use of its delegates at Brussels July, 1919, be printed in connection with similar surveys to be prepared by the various divisions.

Moved: That the Executive Board initiate a survey of the past history, present status, and future work of international organizations in science along the lines followed in the statements prepared for the benefit of the International Geophysical Union. (*Adopted.*)

Moved: That Railroad and Pullman fare of members attending the preliminary organization meeting of the Division of Educational Relations on June 25, and such other expenses pertaining thereto as the Chairman of the Council may direct, be paid from the General Maintenance Fund of the Executive Board. (*Adopted.*)

The work of the Committee on Reconstruction Problems was discussed, and it was

Moved: That the question of publication of reports of the Committee on Reconstruction Problems as a whole or of its members be referred to Mr. Vernon Kellogg, Chairman of the Committee, with power. (*Adopted.*)

The Chairman announced that Mr. A. L. Barrows, Secretary of the Division of States Relations and of Educational Relations, would arrive on June 27. After discussion of the future work of these Divisions it was

Moved: That Mr. J. C. Merriam be appointed non-resident Chairman of the Division of States Relations, without salary. (*Adopted.*)

With reference to the situation created by the resignation of Messrs. Hale and Johnston as chairman and secretary, respectively, of the Council, it was

Moved: That by unanimous consent the Executive Board of the National Research Council recognize that Mr. J. C. Merriam, elected Acting Chairman on February 11, 1919, became Chairman on April 30, 1919, on the acceptance of the resignation of Mr. Geo. E. Hale. (*Adopted.*)

Moved: That by unanimous consent the Executive Board of the National Research Council recognize that Mr. A. O. Leuschner, elected Acting Secretary on April 1, 1919, became Secretary on April 16, 1919, on the acceptance of the resignation of Mr. John Johnston. (*Adopted.*)

In behalf of the Committee on Apportionment of Space, Mr. Mathews, Chairman, presented a plan for the allotment of space in the new quarters of the Council at 1201 Sixteenth Street, to the Divisions of the Council. The report was approved as presented.

On recommendation of Mr. Dunn it was

Moved: That Mr. Mathews be added to the Committee on Removal of Offices of the National Research Council. (*Adopted.*)

The Secretary submitted a provisional budget for the National Research Council for 1919–20 based on the available funds for general maintenance and prepared by the Committee on Budget with the assistance of the Committee on Organization of Administration. The budget is to be supplemented later with estimated expenditures from funds available for special purposes. In the provisional budget is included the complete salary list of officers and employees of the Council and all appropriations to the Executive Board and to the various Divisions, of funds for general maintenance, including traveling expenses, which are subject to the rules of the Council.

Moved: That the general principles adopted in preparing the provisional budget for 1919–20, including the provisional salary list and apportionment of funds be approved with the specification that the budget is to be interpreted as operative for the first half year, from July 1, 1919, to December 31, 1919, and that the Interim Committee have power to make such changes and reductions as may be deemed advisable. (*Adopted.*)

On recommendation of the Secretary, it was

Moved: That the losses on Government funds incurred by foreign exchange be made good from and be charged to the Maintenance Fund of the Executive Board. (*Adopted.*)

Mr. Leuschner, Acting Chairman of the Division of Physical Sciences presented the following resolution of the American Section of the International Astronomical Union:

That the Executive Board of the National Research Council be requested to secure funds for the preparation of a history and bibliography of comets and asteroids, with the understanding that this work will be undertaken in the United States.

Moved: That the securing of the necessary funds for the preparation of a history and bibliography of comets and asteroids be referred to the Committee on Funds for Research Activities. (*Adopted.*)

On recommendation of the Chairman of the Division of Biology and Agriculture, it was

Moved: That the sum of $149.80 to cover the expenses of the Committee on Salt Requirements be reappropriated to the Division of Biology and Agriculture from the unappropriated funds of the National Research Council. (*Adopted.*)

On recommendation of the Chairman of the Division of Biology and Agriculture it was

Moved: That Mr. Lafayette B. Mendel be added to the Committee on Food and Nutrition of the Division of Biology and Agriculture. (*Adopted.*)

In behalf of the Committee on Nomination of Members-at-large of the Executive Board, Mr. Dunn presented for election the names of Mr. R. S. Wood-

ward, President of the Carnegie Institution, Mr. Michael I. Pupin, Professor of Electro-Mechanics, Columbia University, Mr. Raymond Pearl, Biologist, Maine Agricultural Experiment Station, Mr. Edward Dean Adams, 71 Broadway, New York City, and Mr. C. P. Townsend, Patent Lawyer, 918 F Street, Washington, D. C.

Moved: That the Secretary of the Council cast the ballot for the election of Messrs. R. S. Woodward, M. I. Pupin, Raymond Pearl, E. D. Adams, and C. P. Townsend as members-at-large of the Executive Board of the National Research Council, and that the President of the National Academy of Sciences be requested to appoint them members of the National Research Council. (*Adopted.*)

Mr. Leuschner, the Secretary, thereupon reported that he had cast the ballot for Messrs. R. S. Woodward, M. I. Pupin, Raymond Pearl, E. D. Adams, and C. P. Townsend as members-at-large of the Executive Board of the National Research Council, and the Chairman declared these nominees so elected.

It was agreed that the regular meeting of the Executive Board in July should be dispensed with.

The Executive Board adjourned at 1.35 p.m.

PAUL BROCKETT, *Assistant Secretary.*

MINUTES OF THE MEETING OF THE INTERIM COMMITTEE

AT THE NATIONAL RESEARCH COUNCIL BUILDING, 1201 SIXTEENTH STREET NORTHWEST, JULY 1, 1919, AT 9.30 A.M.

Present: Messrs. Angell, Bancroft, H. E. Howe, Leuschner, Mathews, Ransome, and by invitation, A. L. Barrows, Executive Secretary of the Divisions of States and of Educational Relations, H. O. Wood, Assistant to the Secretary of the Council, and J. H. J. Yule, Bursar.

Mr. Angell in the chair.

The reading of the minutes of the previous meeting was dispensed with.

At his suggestion the secretary was instructed to address a letter to each Division regarding the allotment of funds for its use for the current fiscal year, with the suggestion that each Division prepare a budget of estimated expenditures, based on its allotment, to cover general maintenance, traveling expenses, and committee expenses, and with the understanding that no expenditures shall be incurred by a Division for any purpose until an estimate shall have been submitted in advance to the Bursar for each proposed expenditure and until the Bursar shall have certified that a sufficient balance is available in the allotment of the Division.

Moved: That during the absence of the Secretary, Mr. H. E. Howe act as Chairman of the Committee on Budget and as Chairman of the Committee on Organization of Administration, of which the Secretary of the Council is Chairman, and that he be authorized to sign bills in behalf of the secretary. (*Adopted.*)

The Secretary directed attention to the fact that the annual report of the National Research Council to the Council of National Defense should be completed with as little delay as possible and requested that Chairman of Divisions and other executive officers place their material in the hands of Mr. Wood for general assembling during the month of July.

Moved: That the Chairmen of the Divisions and other executive officers of the National Research Council be requested to bring the material as published in the Third Annual Report of the National Research Council presented to Congress down to June 30, 1919, and that these reports be submitted to the Assistant to the Secretary by July 15, 1919. (*Adopted.*)

The Secretary read a communication from Col. L. H. Ruggles, Chief of the Technical Staff of the Ordnance Office dated June 27, in which coöperation is requested in securing experts in dynamics and mathematics. The Secretary was requested to send copies of this communication to the Chairman of the Division of Physical Sciences, the Division of Engineering, and the Division of Chemistry and Chemical Technology.

Moved: That the Interim Committee, acting for the Executive Board is in favor of a change of name from the Division of Industrial Relations to the Division of Industrial Research, if the Division of Industrial Relations submits a definite recommendation to that effect. (*Adopted.*)

The Interim Committee adjourned at 12.30 p.m., to meet again on July 15, 1919.

PAUL BROCKETT, *Assistant Secretary.*

MINUTES OF THE MEETING OF THE INTERIM COMMITTEE

AT THE NATIONAL RESEARCH COUNCIL BUILDING, JULY 15, 1919, AT 9.30 A.M.

Present: Messrs. Angell, Bancroft, Barrows, H. E. Howe, Kellogg, Mathews, Ransome, Wood, Yerkes, and, by invitation, J. H. J. Yule.

Mr. Angell in the chair.

The minutes of the Interim Committee of July 1, 1919, were approved as circulated.

The Bursar raised the question as to method to be adopted by the Council for computing annual or monthly compensation for services.

Moved: That the following rules for compensation of any person in the Service of the United States Government be approved for the computation of pay for services rendered to the Council. (*Adopted.*)

PAYMENT OF SALARIES AND COMPENSATION

1914
Department Circular No. 35

TREASURY DEPARTMENT
OFFICE OF COMPTROLLER OF THE TREASURY
Washington, August 18, 1914.

Comptroller of the Treasury.

The following information is given for computing annual or monthly compensation for services rendered the United States.

The Act of Congress approved June 30, 1906 (34 Stat., 763) provides as follows:

Sec. 6. Hereafter, where the compensation of any person in the service of the United States is annual or monthly the following rules for division of time and computation of pay for services rendered are hereby established:

Annual compensation shall be divided into twelve equal installments, one of which shall be the pay for each calendar month; and in making payments for a fractional part of a month one-thirtieth of one of such installments, or of a monthly compensation, shall be the daily rate of pay. For the purpose of computing such compensation and for computing time for services rendered during a fractional part of a month in connection with annual or monthly compensation, each and every month shall be held to consist of thirty days, without regard to the actual number of days in any calendar month, thus excluding the thirty-first of any calendar month from the computation and treating February as if it actually had thirty days. Any person entering the service of the United States during a thirty-one day month and serving until the end thereof shall be entitled to pay for that month from the date of entry to the thirtieth day of said month, both days inclusive; and any person entering said service during the month of February and serving until the end thereof shall be entitled to one month's pay less as many thirtieths thereof as there were days elapsed prior to date of entry: *Provided*, That for one day's unauthorized absence on the thirty-first day of any calendar month one day's pay shall be forfeited.

This act is construed as requiring that—

1. Each calendar month shall consist of thirty days, and the computation of salary shall be by each month separately, one-twelfth of an annual salary constituting the compensation of each month.

2. One-thirtieth of a monthly installment of salary is to be allowed each day of service from the first to the thirtieth, inclusive. The last day of February counts as three days of service for pay purposes (two days in leap years).

3. The thirty-first day of a month enters into the computation of salary only where there is *one day's* absence in a nonpay status on that day—that is, absence in a nonpay status did not occur also on the thirtieth. For such absence on the thirty-first one day's pay is forfeited.

Reference is made to 20 Comp. Dec., 772 and 867.

Department circulars No. 46 of 1904 and No. 67 of 1906, are superseded.

Approved:

WM. P. MALBURN, *Acting Secretary of the Treasury.*
GEO. E. DOWNEY, *Comptroller.*

Moved: That it is the interpretation of the Interim Committee of the motion of March 18, 1919 that all terms of service expire on June 30 of the appropriate year. (*Adopted.*)

Considering the question of incidental printing of the Divisions, it was the sense of the Interim Committee that the Chairman would charge such expenses to their own divisional allotments unless special approval had been received from the Interim Committee for the cost to be paid from other funds.

Moved: That the Chairman of the National Research Council appoint an Editorial Committee of three members to consider the matters of printing relating exclusively to the Council and its work, to consist of the Chairman of the Council, the Secretary of the Council, and the Chairman of the Research Information Service. (*Adopted.*)

Considering the question raised by Mr. Clevenger, Acting Chairman of the Division of Engineering as to when the term of service of the Committees of the Divisions expires,

This matter was referred to the Committee on Organization of Administration.

Mr. Barrows, Executive Secretary of the Division of Educational Relations presented the following nominations:

Representing the National Association of State Universities—Frank L. McVey, President University of Kentucky, Lexington.

Representing the Bureau of Education—S. P. Capen, Specialist in Higher Education, Bureau of Education, Washington, D. C.

Moved: That the nominations of Messrs. Frank L. McVey and S. P. Capen be approved, with recommendation to the President of the National Academy of Sciences that they be appointed members of the National Research Council, and assigned to the Division of Educational Relations. (*Adopted.*)

On recommendation of the Treasurer, Mr. Ransome, it was

Moved: That the Treasurer be authorized to send the following letter to the Chairman of Divisions and that the Chairman be requested to furnish the information sought as promptly as possible:

My dear Mr. ————

Inasmuch as it is highly important that all funds donated for the work of the National Research Council should be accounted for in a thoroughly business-like manner and to the complete satisfaction of the donors, you are requested to submit to the Treasurer a concise, carefully ordered statement concerning each fund from which expenditures under your control are made. The statement should be arranged under the following heads:

1. Source of the fund.
2. Purpose of the fund as stated by donor.
3. Amount of the fund.
4. Plan or times of payment.
5. Conditions of accounting, including items or head under which expenditures are to be classified by you, as the basis for financial statements to the donor of the fund.

The Treasurer proposes to submit these statements, with the attached form of letter, to the donors of the funds in order to ascertain whether there is complete understanding between each donor and the National Research Council. If you prefer, the letter accompanying this reference, although it should conform as closely as possible to the Treasurer's draft, can be sent over your own signature. After such submission and certification the statements will serve as the Treasurer's guide and authority in all subsequent payments from these funds and in his statements of account to the donors.

Very truly yours,

.....

Treasurer.

My dear Mr. ———

It has seemed desirable in connection with the reorganization of the National Research Council on a peace basis to bring together and to place definitely on record the objects and the conditions of gift of the various funds donated for the work of the Council. The following statement concerning the fund ..... has been drawn up by ...., Chairman of the Division ..... who controls the expenditure of this fund. May I ask you to examine this statement and to inform me whether it is in essential agreement with your record and particularly whether the mode of accounting for expenditures from this fund is entirely satisfactory to .....

Yours very truly,

.....

Treasurer.

Concerning the matter of the organization of the Division of Educational Relations it was

Moved: That the Interim Committee recommend to the Executive Board the approval of the election of Mr. Vernon Kellogg as Chairman of the Division of Educational Relations. (*Adopted.*)

The question of traveling expenses of Chairmen of Divisions when called to Washington while on leave of absence was considered. After discussion it was

Moved: That when members of the Executive Board or of the Interim Committee on leave are required to travel to Washington on official business their traveling expenses, when approved by the Chairman, shall be paid by the National Research Council. (*Adopted.*)

The Chairman reported that the Psychology Section of the Division of Anthropology and Psychology was in process of organization.

The Interim Committee adjourned at 11.10 a.m. to meet at the call of the Chair.

PAUL BROCKETT, *Assistant Secretary.*

MINUTES OF THE MEETING OF THE EXECUTIVE BOARD OF THE NATIONAL RESEARCH COUNCIL ON AUGUST 12, 1919

AT THE OFFICE OF THE NATIONAL RESEARCH COUNCIL AT WASHINGTON, D. C.

The meeting was called to order at 9.55 a.m. with Mr. Angell in the chair.

Present: Messrs. Abbot, Adams, Angell, Barrows, Flinn, H. M. Howe, H. E. Howe, Hussey, Johnston, Kellogg, Ransome, Wood, Woodward, Yerkes, and by invitation J. H. J. Yule.

The minutes of the meeting of the Executive Board of the National Research Council of June 24 were approved as circulated with certain textual corrections.

The Treasurer, Mr. Ransome, presented a financial statement for the month of June, stating that the report for July was in preparation and would be distributed shortly.

Mr. Woodward, as chairman of a committee appointed at the meeting of the Executive Board on May 8, 1919, recommended for approval the following resolution:

WHEREAS the inauguration of any important enterprise for the improvement and progress of communities or states requires that its affairs be conducted by men whose altruism and fidelity command confidence; and whereas the office of Treasurer of the National Academy of Sciences and of the National Research Council, held by Mr. Whitman Cross during the past year and four months, is a position of vital and exacting responsibilities, therefore, be it

RESOLVED, That the National Research Council hereby expresses and records its cordial appreciation of the laborious and painstaking services rendered by Mr. Cross during this formative period of the Council, when there was special need of the patriotism and the altruism he displayed in his work.

Moved: That the report of the Committee be accepted by the Executive Board as expressing its appreciation of the services rendered by the Treasurer, Mr. Whitman Cross, and that the Secretary be instructed to transmit a copy of this minute and report to Mr. Whitman Cross. (*Adopted.*)

Mr. Kellogg, Chairman of the Division of Educational Relations presented the following recommendations:

In compliance with action of the Interim Committee at its meeting on June 17, 1919, it is recommended, after discussion and agreement with the Executive Committee of the Division of Biology and Agriculture at its recent meeting at Woods Hole, that informal liaison be maintained between the Committee on Educational Relations of the Division of Biology and Agriculture and the Division of Educational Relations through the chairmen of these Divisions, instead of by the appointment of a liaison member from the former in the latter Division.

The question of coördination of Divisions of Science and Technology with the Division of Educational Relations has been considered. It is believed that the action of the Interim Committee on June 17, to the effect that chairmen of divisions be present whenever possible at the meetings of other divisions, sufficiently covers this situation, and it is recommended that this system be developed and maintained.

Moved: That the recommendations of the Division of Educational Relations be approved. (*Adopted.*)

The following nominations were presented by the Chairman of the Division of Educational Relations for membership in that Division:

Representing the Association of American Universities—President A. Ross Hill, University of Missouri, Columbia, Mo.

Representing the American Association of University Professors—Professor E. Percival Lewis, Professor of Physics, University of California, Berkeley, California.

Moved: That the nominations of President A. Ross Hill, of the University of Missouri, and Professor E. Percival Lewis, of the University of California, be approved, with recom-

mendation to the President of National Academy of Sciences that they be appointed members of the National Research Council and assigned to the Division of Educational Relations. (*Adopted.*)

Moved: That the appointment of Mr. Vernon Kellogg as Chairman of the Division of Educational Relations as of July 15, 1919, be approved. (*Adopted.*)

Mr. Yerkes, Chairman of the Research Information Service, asked further consideration of the price to be charged for certain bulletins of the National Research Council.

Moved: That the price of certain bulletins be fixed at one cent a page instead of one-half cent a page. *Adopted.*

Moved: That in each case the authors be requested to indicate if they desire separates, and that the Board authorize the supplying of fifty copies of a reprint to each of the authors gratis. (*Adopted.*)

In compliance with action of the Interim Committee at its meeting on June 17, 1919, which provided that the Research Information Service be instructed to investigate and report on the desirability of preparing for publication a record of the work of scientific men in connection with the War, Mr. Yerkes, Chairman of the Division reported a diversity of opinion in the several Divisions, and recommended as a result of his investigation that action with reference to this matter be left, at least for the present, entirely to the initiative of the Divisions.

Moved: That the report and recommendation of the Chairman of the Research Information Service be approved. (*Approved.*)

Mr. Yerkes asked consideration of the preparation of a volume in the Century Series on "The War and Science," which he has in preparation in coöperation with Mr. H. M. Howe.

Moved: That Mr. Yerkes and Mr. Howe be authorized and requested to prepare the manuscript on the volume in the Century Series, entitled "The War and Science," without expense to the Council. (*Adopted.*)

Moved: That the Research Information Service be required to establish and maintain a Personnel Bureau in connection with the service, which shall include a research personnel list in science and technology. (*Adopted.*)

Moved: That Mr. G. S. Fulcher be appointed Scientific Associate from July 1, 1919. (*Adopted.*)

Mr. H. M. Howe, Chairman of the Division of Engineering, presented the resignation of Mr. G. H. Clevenger as Vice Chairman of the Division.

Moved: That the resignation of Mr. Clevenger be accepted with regret, and that a vote of thanks of the Board be extended to him for efficient and faithful service. (*Adopted.*)

Mr. Howe presented an informal statement of the work of the Division of Engineering.

Mr. Howe presented to the Executive Board his resignation as Chairman of the Division of Engineering.

Moved: That the resignation of Mr. Henry M. Howe as Chairman of the Division of Engineering be accepted with regret, and that the National Research Council desires to express its appreciation of the valuable services which Mr. Howe has rendered to the Council in its work, both as Chairman of the Division of Engineering, and as Scientific Attaché of the United States and representative of the Research Information Service at Paris. (*Adopted.*)

Mr. Howe inquired whether there was any objection on the part of the Executive Board to the printing of the scientific papers prepared by those connected with the Division in scientific journals provided due credit was given to the Council for the work.

Moved: That on the title page of scientific papers from the Division of Engineering published in journals other than those of the National Academy of Sciences and the National Research Council, a footnote be included to read as follows: "Progress Report on Research under the Division of Engineering, National Research Council." (*Adopted.*)

Moved: That the name of the Committee on "Improvements of Metals at Blue Heat" be changed to "Physical Changes in Iron and Steel Below the Thermal Critical Range." (*Adopted.*)

Moved: That the Research Committee of the American Bureau of Welding be designated as The Welding Research Committee of the Division of Engineering of the National Research Council. (*Adopted.*)

Moved: That the Executive Board approve of the publication of a booklet on the relation of the Engineering Foundation to the National Research Council, if funds are provided. (*Adopted.*)

Mr. Hussey, Vice-Chairman of the Division of Medical Sciences presented the following nominations for membership in that Division:

Representing the American Anatomical Society—Professor Clarence M. Jackson, University of Minnesota.

Representing the American Neurological Society—Dr. E. E. Southard, 74 Fenwood Road, Boston, Mass.

Moved: That the nominations of Professor Clarence M. Jackson and Dr. E. E. Southard be approved, with recommendation to the president of the National Academy of Sciences that they be appointed members of the National Research Council and assigned to the Division of Medical Sciences. (*Adopted.*)

Moved: That the Division of Medical Sciences, in view of the special conditions presented by Mr. Hussey, Vice-Chairman of the Division, be authorized to act in the election of a representative from the Public Health Service on the Division of Medical Sciences, subject to the approval of the Council of the National Academy of Sciences. (*Adopted.*)

The Chairman of the Council stated that Dr. Christian would report for duty as Chairman of the Division of Medical Sciences on October 1, 1919.

The Chairman of the Council presented the following report from the Executive Committee of the Division of Biology and Agriculture:

1. That Miss Isabel Bevier, Head of the Department of Domestic Science of the University of Illinois has been recommended for appointment on the Committee on Human Nutrition, and Mr. W. H. Jordan of the New York Agricultural Station at Geneva and President Raymond A. Pearson of the State Agricultural College of Iowa, Ames, Iowa, for appointment on the Committee on Animal Nutrition.

2. That Messrs. L. O. Howard, W. E. Osgood, C. E. Allen, K. F. Kellerman, G. M. Duggar have been appointed as new members of the Committee on Coöperation and Coördination.

3. That the Organization Committee on Forestry has been made a standing committee of the Division. (*Approved.*)

The Chairman of the Council also presented the following recommendation of the Executive Committee of the Division of Biology and Agriculture:

That in connection with the matter of the needs of the Marine Biological Laboratory a sum of money (about $130,000 will be needed) be appropriated for the construction, equipment, and maintenance of a new laboratory as outlined in the report of the Committee on the Marine Biological Laboratory; and that the annual sum of $5000 for five years be also appropriated for use in connection with accessions for the Marine Biological Laboratory Library.

After considerable discussion of the purposes of the Council, it was

Moved: That further consideration of this matter be postponed until the next meeting of the Executive Board. (*Adopted.*)

But as an outcome of the general discussion it was further

Moved: That the National Research Council give its moral support to the work of the Marine Biological Laboratory at Woods Hole, approve the program of the Laboratory for the enlargement of its facilities for scientific research, with the statement that active steps for the encouragement of this work are under consideration. (*Adopted.*)

It was the understanding that a copy of this minute, together with descriptive material, would be mailed to the members of the Executive Board for their consideration, and that the matter would come up for further action at the next meeting.

The Chairman of the Council also presented, for the Executive Committee of the Division of Biology and Agriculture the recommendation that a publication fund of $20,000 per year for a period of five years be granted to that Division.

Moved: That the Finance Committee of the National Research Council be instructed to consider and if practicable secure a publication fund of $20,000 per year for a period of five years to be appropriated to the Division of Biology and Agriculture. (*Adopted.*)

It was understood that the Division of Biology and Agriculture would control the expenditure of this fund.

The Executive Board took a recess at 1.50 to meet again at 3.00 p.m.

The Executive Board resumed its meeting at 3 p.m.

The following nomination was presented by Mr. Barrows, Executive Secretary of the Division of States Relations for membership in that Division:

Representing the Association of American State Geologists—Mr. Frank W. DeWolf, State Geologist of Illinois, Urbana, Illinois.

Moved: That the nomination of Mr. Frank W. DeWolf be approved with the recommendation to the President of the National Academy of Sciences that he be appointed a member of the National Research Council and assigned to the Division of States Relations. (*Adopted.*)

The following nominations for the Divisions mentioned, as members in the Division of States Relations were approved:

Industrial Relations	Mr. H. E. Howe
Chemistry and Chemical Technology	Mr. W. D. Bancroft
Geology and Geography	Mr. E. B. Mathews
Educational Relations	Mr. Vernon Kellogg

The following motion was presented:

Moved: That, beginning July 1, 1919, following each regular meeting of the Executive Board, a bulletin be published which shall include at the discretion of the Secretary the minutes and records of action of the Executive Board, and of the Interim Committee, of Divisions and of their Executive Committees, and of other administrative committees of the Council, for the interval following the preceding meeting of the Executive Board.

Moved: That the motion be laid on the table. (*Adopted.*)

The following motion relating to a bulletin on the History of the Organization of the National Research Council was presented:

Moved: That a bulletin be published to record the actions taken to effect the permanent organization of the National Research Council, and of its several Divisions, which shall include at the discretion of the Secretary pertinent minutes and records of actions of committees, governing boards, and Divisions. (*Adopted.*)

Mr. Wood presented a mimeographed copy of the organization of the National Research Council as of June 24, 1919, which he had prepared, stating that the lists were not entirely complete.

Moved: That this organization be held until complete, and then included in the bulletin of the history of the organization. (*Adopted.*)

The Chairman stated that Mr. Leuschner would not be able to return to the Council to continue as Secretary, and that the Council appreciated the work he had done as Secretary and the sacrifice which he had made in leaving his scientific work in California in order to aid at a critical period.

The Chairman also stated that in the absence of Mr. Leuschner the work of the office of the Secretary had been carried on very ably by Mr. Wood, whose services were greatly appreciated by the Council.

Following the instructions of the Interim Committee at its meeting of July 15, 1919, Mr. H. E. Howe, as Chairman of the Committee on Organization of Administration, presented the following motions:

Moved: That beginning with this date all committees of the Council and its Divisions shall terminate June 30, 1920 and thereafter all committees except Executive Committees of Divisions shall unless previously discharged terminate on June 30 of each year. (*Adopted.*)

Moved: That the Executive Committees of Divisions shall be elected at the annual meetings for the succeeding year. (*Adopted.*)

Mr. Hussey suggested that two committees, one on Organization of Administration and the other the Budget Committee, be combined.

Moved: That the Committee on Organization of Administration and the Budget Committee be discharged, that the joint functions of the two committees be combined, and that the Chairman be authorized to appoint a new committee of three on Organization and Budget. (*Adopted.*)

The Chairman thereupon appointed the following to serve on this Committee: Mr. H. E. Howe, Chairman, Mr. F. L. Ransome, Mr. Vernon Kellogg.

Moved: That the Chairman be authorized to appoint a committee of three on publicity, with Mr. Vernon Kellogg as Chairman. (*Adopted.*)

The Chairman thereupon appointed the following to serve with Mr. Kellogg on this committee: Mr. R. M. Yerkes, Mr. H. E. Howe.

The Chairman announced to the Executive Board the death of Mr. Andrew Carnegie, philanthropist, and it was the unanimous opinion of the Board that resolutions should be adopted showing the appreciation of what Mr. Carnegie had done for the advancement of scientific research.

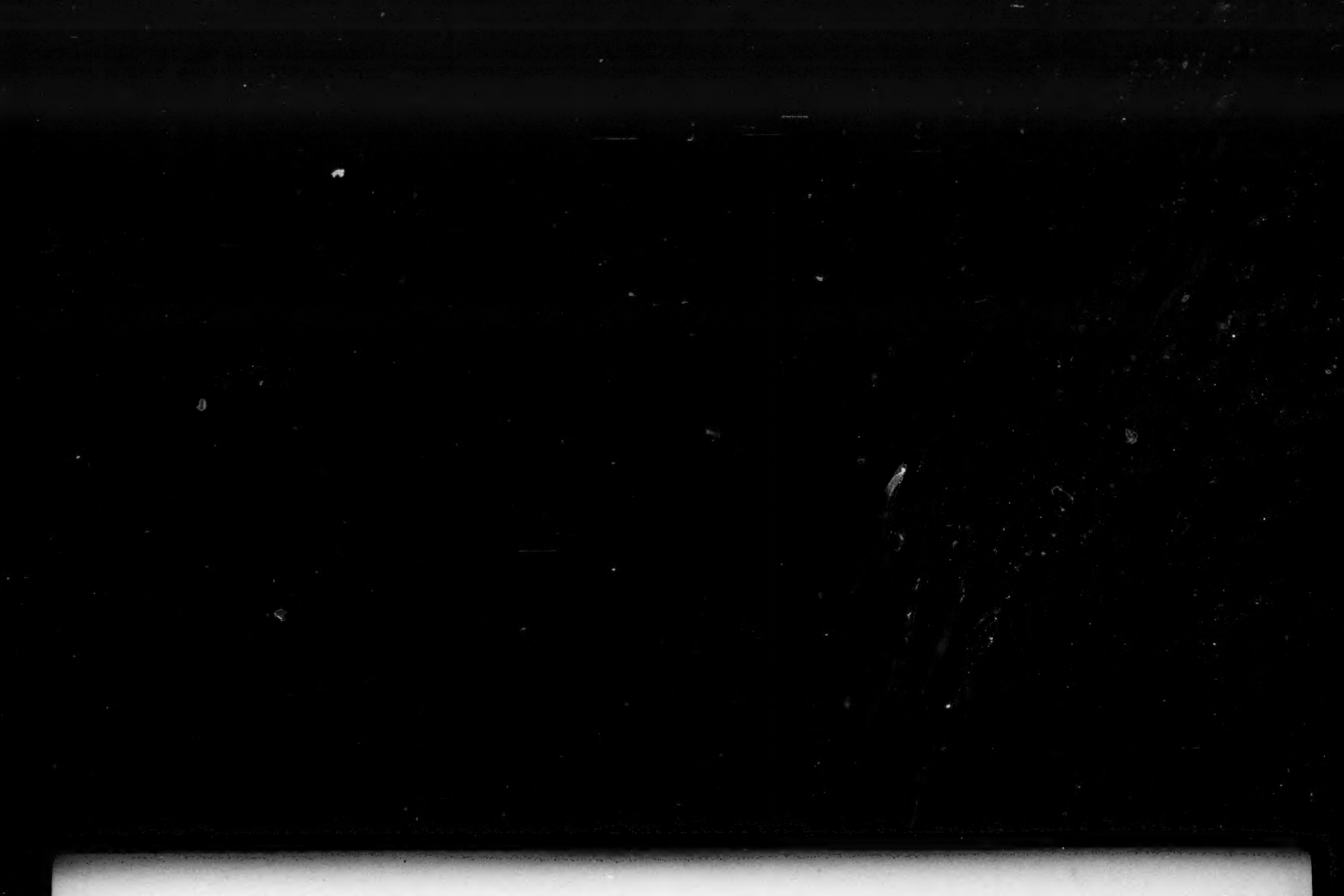
Moved: That the Chairman be authorized to appoint a committee to draft resolutions regarding the life and work of Mr. Carnegie, and to report at the next meeting of the Executive Board. (*Adopted.*)

The Chairman thereupon appointed the following to serve on this committee: Mr. R. S. Woodward, Chairman, Mr. C. D. Walcott.

The Chairman, Mr. Angell, presented a communication from Mr. Benjamin S. Hanchett, Regent of the University of Michigan, addressed to and enclosed with one from Mr. M. E. Cooley, Dean of the Colleges of Engineering and Architecture of Michigan concerning a proposed industrial research laboratory at the University of Michigan, which is to be established through gifts from a Manufacturers Association of the state of Michigan, asking an opinion as to the advisability of the University of Michigan entering into this new field. These communications are filed in the office of the Chairman of the Council.

Moved: That if invited by the responsible authorities of the University of Michigan the National Research Council is ready to express an opinion in the matter. (*Adopted.*)

Moved: That the Executive Board adjourn to October 14, 1919, subject to the call of the Chair. (*Adopted.*)

The meeting adjourned at 4.50 p.m.

PAUL BROCKETT, *Assistant Secretary.*